

REMARKS

Claims 1-24 are pending in this application. By this Amendment, Applicant has amended claims 1-24. Support for the amendment is found in the specification. Additionally, Applicant has amended the specification for clarity. No new matter is added.

This Response is submitted as a complete and full reply to the outstanding Office Action. In view of the above amendments and following remarks, Applicant respectfully requests reconsideration of this application.

MATTERS OF FORM

The Office Action objects to the specification for informalities. Applicant has reviewed the specification and has made several amendments to better clarify and to improve the readability of the specification. As a courtesy, Applicant encloses a Substitute Specification with a marked-up copy. Therefore, in view of the amendments to the specification, Applicant respectfully requests the withdrawal of the objections to the specification.

The Office Action objects to claims 17, 18 and 22 asserting informalities. Applicant has amended the claims to obviate the objection. Accordingly, withdrawal of this objection is respectfully requested.

The Office Action rejects claim 1 under 35 U.S.C. § 112, first paragraph, asserting that the disclosure is not enabling. This rejection is respectfully traversed.

Applicant respectfully submits that the subject matter of claim 1 is supported in the description regarding the first and second Faraday cups (flag and disc) 12 and 14,

both of which serve to measure beam electric currents I_F and I_D , respectively, as described on page 10 of the Applicant's specification. It is well known in the art that a Faraday cup or cage is used to measure or detect charged particles in the form of electric currents. Therefore, the term "beam energy" may be quantified in terms of beam electric current, for example. Accordingly, the term "beam electric current", as recited in claim 1, is within the understanding of one of ordinary skill, and does not introduce new matter.

In view of the above, Applicant respectfully submits that the language of claim 1 satisfies the requirements of 35 U.S.C. § 112, first paragraph. Therefore, Applicant respectfully requests withdrawal of this rejection.

The Office Action rejects claims 1, 2, 6-9, 15, 17, 18, 20 and 23 under 35 U.S.C. § 112, second paragraph, asserting indefiniteness. Applicant has amended the claims to obviate this rejection. Accordingly, Applicant respectfully requests withdrawal of this rejection.

The Office Action rejects claim 4 under 35 U.S.C. § 101, asserting non-statutory subject matter. Applicant has amended claim 4 to obviate this rejection. Accordingly, Applicant respectfully requests withdrawal of this rejection.

PATENTABLE SUBJECT MATTER

The Office Action rejects claims 1-24 under 35 U.S.C. § 103(a) over Adibi et al. (U.S. Patent No. 5,883,391). This rejection is respectfully traversed.

Applicant's independent claim 1 recites an ion implantation apparatus for use in implanting an ion beam into a wafer by conducting the ion beam to the wafer along a

predetermined path, the ion implantation apparatus comprising, means for measuring, along the predetermined path, beam electric currents at a plurality of measurement positions different from each other, means for obtaining a beam transport efficiency between the measurement positions from the beam electric currents measured at respective measurement positions to estimate a ratio of energy contamination specified by a neutralized ion beam and a desired ion beam both of which are implanted in the wafer, by using a correlation between the energy contamination and the beam transport efficiency.

Applicant's independent claim 7 recites the ion implantation method for use in an ion implantation apparatus comprising an ion source, an extraction electrode, a mass analysis unit, a mass analysis slit, and a wafer processing chamber, comprising the steps of, deciding a target value of energy contamination in a wafer, measuring, along a predetermined path, beam electric currents at a plurality of measurement positions different from each other to obtain a beam transport efficiency of an ion beam, and adjusting transport efficiency and the energy contamination.

Applicant's independent claim 9 recites a method of implanting ions into a wafer, comprising the steps of, setting a beam transport efficiency to a predetermined value to decrease a neutral fraction of the beam, and monitoring the beam transport efficiency to reduce an energy contamination to a value lower than a target value.

Applicant's independent claim 10 recites an ion implantation apparatus comprising an ion source, an extraction electrode, a mass analysis unit, a mass analysis slit, and a wafer processing chamber, the apparatus having a measurement

point determined at an intermediate convergent point or at a front or rear position of the mass analysis slit and being controlled so that a neutral fraction of a beam becomes lower than a predetermined rate.

Applicant's independent claim 24 recites the ion implantation apparatus, comprising, a table for storing measured results in necessary beam electric current values on the basis of an inverse proportion relation between a beam transport efficiency in each ion species and an amount of an energy contamination, and means for adjusting the energy contamination of ion implantation in the each necessary beam electric current value, by using a limit beam transport efficiency value obtained on the basis of the table.

Adibi discloses an ion implantation apparatus and a method of monitoring high energy neutral contamination in an ion implantation process. Adibi points out that a problem of high energy contamination on a target substrate arises when an ion beam is temporarily accelerated when emerging from an exit aperture of a flight tube before being subsequently decelerated down to the implant energy (column 2, lines 19-23). Any ions neutralized while at the temporary higher energy will continue to implant in the target substrate at the higher energy and the energy of contaminating neutrals is higher than the transport energy (column 2, lines 23-27).

Ions emerging from the exit aperture of the flight tube are temporarily accelerated to a higher energy if there is a field electrode between the exit aperture and the target substrate which is at a negative potential difference relative to the flight tube. Such a negative field electrode may be used as an electron suppression electrode designed to

prevent electrons in the ion beam emerging from the flight tube from being drawn out of the beam in the flight tube by the deceleration field which reduces the energy of the ions down to the implant energy (column 2, lines 29-39).

Under these circumstances, a current drain is monitored on the field electrode because it provides a good indication of the amount of contamination of the target substrate (column 2, lines 59-61). This electrode current drain provides a direct measure of the energy contamination on the target substrate at energies above the transport energy of ions through the flight tube (column 3, lines 2-5). The field electrode current drain may be precalibrated as a measure of the neutralised ion flow (column 3, lines 6-8).

The monitored current drain is compared with a threshold value selected to correspond to a maximum tolerable level of the high energy neutral contamination (column 3, lines 9-12).

In the embodiment of Adibi, an electrode assembly 9 for controlling the implant energy of the ion beam is situated just beyond a screening assembly 52 and comprises the field electrode 61 and the deceleration electrode 65 (column 5, lines 51-54). The field electrode 61 is biased to a potential lower than the potential of the flight tube and serves to prevent electrons in the mass resolving region from being drawn to the deceleration electrode 65 (column 7, lines 14-17).

With this structure, the beam is briefly accelerated above the transport energy of 10 keV to an energy defined substantially by the potential difference between the ion source 15 and the field electrode 61, typically 25 keV. The beam passes through the

field electrode aperture 63 and is then decelerated to substantially the required implant energy in the gap between the field electrode aperture 63 and the final aperture 67 of the deceleration electrode 65 (column 7, lines 21-29).

By adopting the above-mentioned structure, the beam ions which are neutralised as they pass the field electrode 61 experience electron exchange with a residual gas atom, resulting in a low energy residual gas ion which is positively charged. Such low energy residual gas ions are attracted to the negative potential on the field electrode 61, at which they are discharged to contribute to the current drain on the electrode 61 (column 8, lines 10-16).

A current meter 80 provides a signal on a line 81 indicative of the current drain on a power supply 77 maintaining the field electrode 61 at the desired potential. The current data signal on the line 81 is supplied to a calibration and utilisation unit 82 (column 8, lines 17-21). The calibration and utilisation unit 82 may be a threshold detector which has been set to generate an alarm signal if the signal on the line 81 indicates the current drain on the electrode 61 exceeds a predetermined threshold value (column 8, lines 22-26). The current drain may be delivered to a calibration unit 94 of a system controller 91 illustrated in Fig. 2.

Signals from the calibration unit 94 are supplied to compensatory control and/or interlock unit 96 within the system controller 91. The unit 96 may be arranged to respond to high levels of current drain on the electrode 61 by adjusting other system parameters with a view to controlling the level of high energy neutral contamination in the beam (column 9, lines 1-4).

From the above, it is readily understood that Adibi is mainly directed to the current data signal on the line 81 connected to the field electrode 61 and not to the beam collector 14. As illustrated in Fig. 1, the beam collector 14 is positioned downstream of the substrate support 11 which serves as a beam stop and ion current detector for dosimetry measurements (column 4, lines 37-40). This demonstrates that no consideration is made at all in Adibi regarding utilizing any other drain or current than the current drain of the field electrode 61, so as to monitor the high energy neutral contamination. In other words, only the current drain of the field electrode 61 is used to indirectly estimate the high energy neutral contamination in the vicinity of the electron suppression electrode, namely, the deceleration electrode 65. Thus, the absolute quantity of the high energy neutral contamination is monitored or controlled by indirectly estimating an absolute quantity of a high energy neutral beam only at one position adjacent to the electron suppression electrode 65.

It is noted that a beam ion that is neutralized is no longer affected by magnetic or electric fields, as pointed out by Adibi (column 7, lines 50-51) and, therefore, the neutralized beam ion can not be directly electrically monitored or controlled.

Therefore, Adibi does not disclose or even consider the possibility of measuring electric currents at a plurality of positions placed along a beam line or relatively estimating a high energy neutral beam on the basis of results measured at the plurality of the positions along the beam line.

In contrast, Applicant's independent claims 1, 7, 10, and 24 recite measuring electric currents at a plurality of positions placed along a beam line to estimate a high

energy neutral beam and to control or adjust a ratio of energy contamination to a value less than a predetermined one. Practically speaking, the ratio CE_{ne} of the energy contamination between a desired ion beam and a neutralized ion beam can be controlled on the basis of Equation 6, for example, as described in the Applicant's specification, by using a beam transport efficiency obtained or calculated from the measured electric currents. Thus, measuring the electric currents at the plurality of the positions can be very significant to determining the beam transport efficiency. It should be noted that the beam transport efficiency determined mentioned above can be representative of an efficiency between a Faraday flag 12 and a Faraday disc 14 and may be recognized as a relative value, not an absolute value measured at a single point alone.

As suggested by Adibi (column 8, lines 3-15), such a single measured value may not be precise because it may include secondary electrons resulting from bombardment of beams. However, Adibi never teaches about measuring a beam transport efficiency between two points to obtain a ratio of energy contamination.

On the other hand, the Applicant's invention makes it possible to precisely estimate the ratio of the energy contamination between the desired ion beam and the neutralized ion beam by observing the electric currents at the plurality of the positions.

Claims 2-6 depend from claim 1; claim 8 depends from claim 7; and claims 11-23 depend from claim 10. Thus, in view of the above remarks, Applicant respectfully requests the withdrawal of this rejection for at least the above reasons, Applicant

respectfully submits that Adibi does not disclose or suggest all the features of the Applicant's claimed invention.

CONCLUSION

In view of the above, Applicant respectfully submits that all of pending claims 1-24 contain patentable subject matter. Favorable consideration and prompt allowance is earnestly solicited.

Should the Examiner believe that anything further is necessary to place this application in even better condition for allowance, the Examiner is invited to contact the Applicant's undersigned attorney at the telephone number listed below.

In the event this paper is not considered to be timely filed, Applicant respectfully petitions for an appropriate extension of time. The Commissioner is authorized to charge payment for any additional fees which may be required with respect to this paper to Counsel's Deposit Account 01-2300, referring to client-matter number 107443-00007.

Please charge any fee deficiency or credit any overpayment to Deposit Account
No. 01-2300, referencing attorney docket number 107443-00007.

Respectfully submitted,



Jonathan A. Kidney
Registration No. 46,195

Customer No. 004372
ARENT FOX KINTNER PLOTKIN & KAHN, PLLC
1050 Connecticut Avenue, N.W.,
Suite 400
Washington, D.C. 20036-5339
Tel: (202) 857-6000
Fax: (202) 638-4810

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Enclosures: Marked-Up Copy of Amended Claims
Substitute Specification
Marked-Up Copy of Specification
Petition for Extension of Time (one month)

MARKED-UP COPY OF AMENDED CLAIMS

1. (Once Amended) An ion implantation apparatus for use in implanting an ion beam into a wafer by conducting the ion beam to the wafer along a predetermined path, the ion implantation apparatus comprising:

means for measuring, along the predetermined path, [beam energy] beam electric currents at a plurality of measurement positions different from each other;

means for obtaining a beam [transportation] transport efficiency between the measurement positions from the [beam energy] beam electric currents measured at [the] respective measurement positions to estimate a ratio of [; and

means for reducing] energy contamination specified by a neutralized ion beam and a desired ion beam both of which are implanted in the wafer, by using a correlation between the energy contamination [implanted into the wafer] and the beam [transportation] transport efficiency.

2. (Once Amended) [An] The ion implantation apparatus as claimed in claim 1, the apparatus having an intermediate convergent point or a mass analysis slit for converging the beam within the [predetermine] predetermined path, wherein one of the measurement positions is determined at a front or rear position of the intermediate convergent point or the mass analysis slit, the apparatus being adjusted at [the] one of the measurement positions so that a [rate of a neutral beam to the beam the] ratio of the energy contamination is not higher than a predetermined [rate] value.

3. (Once Amended) [An] The ion implantation apparatus as claimed in claim 2, wherein the correlation is [specified] computed on the basis of a table which stores

measurement data of a special correlation that is featured by an inverse proportion relation between the [beam transportation efficiency and the] ratio of the energy contamination in the wafer and the beam [transportation] transport efficiency.

4. (Once Amended) [An] The ion implantation apparatus as claimed in claim 3, wherein the correlation is specified by an inverse proportion relation between the energy contamination and the beam [transportation] transport efficiency.

5. (Once Amended) [An] The ion implantation apparatus as claimed in claim 1, the apparatus comprising an ion source, an analyzer, an ion deceleration electrode, and a wafer processing chamber, wherein [the] measurement positions are determined at a rear portion of the ion deceleration electrode and an ion implantation position of the wafer processing chamber; wherein

[the] a beam [transportation] transport efficiency being calculated from results measured at [the] respective measurement positions.

6. (Once Amended) [An] The ion implantation apparatus claimed in claim 5, wherein [an amount] the ratio of the energy contamination is determined [with reference to] in consideration of a deceleration [rate based] ratio which is defined by the ratio of implanted ion energy to the extracted ion energy [on the ion deceleration electrode].

7. (Once Amended) [An] The ion implantation method for use in an ion implantation apparatus comprising an ion source, an extraction electrode, a mass analysis unit, a mass analysis slit, and a wafer processing chamber, comprising the steps of:

deciding a target value [in a wafer related to an amount] of energy contamination

in a wafer;

measuring, along a predetermined path, beam electric currents at a plurality of measurement positions different from each other to obtain a beam [transportation] transport efficiency of an ion beam; and

adjusting [the amount of] the energy contamination in the wafer to a value not higher than the target value by the use of a correlation between the beam [transportation] transport efficiency and the energy contamination.

8. (Once Amended) [An] The ion implantation method as claimed in claim 7, further comprising the steps of:

[measuring] obtaining the [ion transportation] beam transport efficiency of the ion beam; and

judging whether or not ion implantation is to be [judged] started [with reference to the target value determined for the energy contamination] by comparing the measured beam transport efficiency with a lower limit.

9. (Once Amended) A method of implanting ions into a wafer, comprising the steps of:

setting a beam [transportation] transport efficiency to a predetermined value to decrease a [rate of a neutral beam to a beam and to thereby enhance a rate of a desired beam to the beam] neutral fraction of the beam; and

monitoring the beam transport efficiency [reducing] to reduce an energy contamination to a value lower than a target value.

10. (Once Amended) An ion implantation apparatus comprising an ion source, an extraction electrode, a mass analysis unit, a mass analysis slit, and a wafer processing chamber, the apparatus having [one of] a measurement [points] point determined at an intermediate convergent point or at a front or rear position of the mass analysis slit and being controlled so that [a rate of neutral beam to a beam] a neutral fraction of a beam becomes lower than a predetermined rate.

11. (Once Amended) [An] The ion implantation apparatus as claimed in claim 10, comprising a first Faraday cup that is located at a first position determined at a front or a rear position of either of intermediate convergent point and the mass analysis slit; a second Faraday cup that is located at a second position determined at a front or rear position of a wafer;

means for measuring beam electric currents at the first and second positions to calculate a difference between the beam electric currents measured at the first and the second positions and to obtain a beam [transportation] transport efficiency with reference to the difference.

12. (Once Amended) [An] The ion implantation apparatus as claimed in claim 10, wherein a deceleration unit is provided with a beam path of an ion beam, and an amount of ion implantation is controlled and adjusted on the basis of a relation between a beam [transportation] transport efficiency obtained by the use of the deceleration unit and an energy contamination.

13. (Once Amended) [An] The ion implantation apparatus as claimed in claim 12, wherein the deceleration unit is composed of a deceleration electrode section;

the apparatus being controlled so that the energy contamination does not exceed an allowable amount on the basis of an inverse proportion relation between a beam [transportation] transport efficiency from the deceleration electrode section to a wafer and the amount of the energy contamination.

14. (Once Amended) [An] The ion implantation apparatus as claimed in claim 13, comprising a first Faraday cup located just after the deceleration electrode section and a second Faraday cup located just after the wafer;

the beam [transportation] transport efficiency before implantation into the wafer being measured by use of the first and second Faraday cups.

15. (Once Amended) [An] The ion implantation apparatus claimed in [claims] claim 11, wherein [the implantation is not carried out by comparing a measured value of the beam transportation efficiency with a predetermined allowable lower limit value and by detecting that the former value does not exceed the latter value] starting of implantation process is inhibited if a measured beam transport efficiency is less than a predetermined allowable lower limit.

16. (Once Amended) [An] The ion implantation apparatus as claimed in claim 10, further comprising:

means for tuning the ion source and a beam [transportation] transport system.

17. (Once Amended) [An] The ion implantation apparatus as claimed in claim 10, further comprising:

means for comparing the measured [value of the] beam [transportation] transport efficiency with the predetermined allowable lower limit [value];

means for stopping the processing of the implantation in the case where the measured [value] beam transport efficiency [does not exceed] is less than the predetermined allowable lower limit [value]; [and]

means for displaying an error message in the case where the implantation is stopped [so as to automatically tune the ion source and the beam transportation system again] and;

means for automatically starting the implantation process again by tuning the ion source and a beam transport system formed between the ion source and the processing chamber.

18. (Once Amended) [An] The ion implantation apparatus as claimed in claim 10, wherein the mass analysis slit is variable in [a slit] width [which adjusts the beam on tuning the beam transportation system] which can be used to precisely adjust a beam orbit when tuning a beam transport system formed between the ion source and the processing chamber.

19. (Once Amended) [An] The ion implantation apparatus as claimed in claim 12, wherein the mass analysis slit is used also as a deceleration electrode.

20. (Once Amended) [An] The ion implantation apparatus as claimed in claim 10, wherein [automatic switching is made to a mass analysis slit of a minimum width on tuning a beam transportation system to adjust a beam axis and to adjust a coil electric current of an analyzer] the mass analysis slit is automatically adjusted to a minimum width to adjust a beam axis by changing electric current of a mass analyzing magnet coil included in the mass analysis unit.

21. (Once Amended) [An] The ion implantation apparatus as claimed in claim 12, wherein the beam [transportation] transport efficiency is measured by a Faraday flag provided just after a deceleration electrode section and a Faraday disk provided just after a wafer.

22. (Once Amended) [An] The ion implantation apparatus as claimed in claim 10, wherein a beam [transportation] transport efficiency is measured before the beam starts to impinge a wafer.

23. (Once Amended) [An] The ion implantation apparatus as claimed in claim 15, wherein a specified [value which serves as the allowable lower limit value is set in compliance with an amount of desired allowable for the] ratio of energy contamination [or] is set in each implantation recipe] a specified ratio of energy contamination is set in each implantation recipe, which is automatically converted to the limit of the beam transport efficiency.

24. (Once Amended) [An] The ion implantation apparatus, comprising:
a table for storing measured results in necessary beam electric current values on the basis of an inverse proportion relation between a beam [transportation] transport efficiency in each ion species and an amount of an energy contamination; and
means for adjusting the energy contamination of ion implantation in the each necessary beam electric current value, by using a limit beam [transportation] transport efficiency value obtained on the basis of the table.